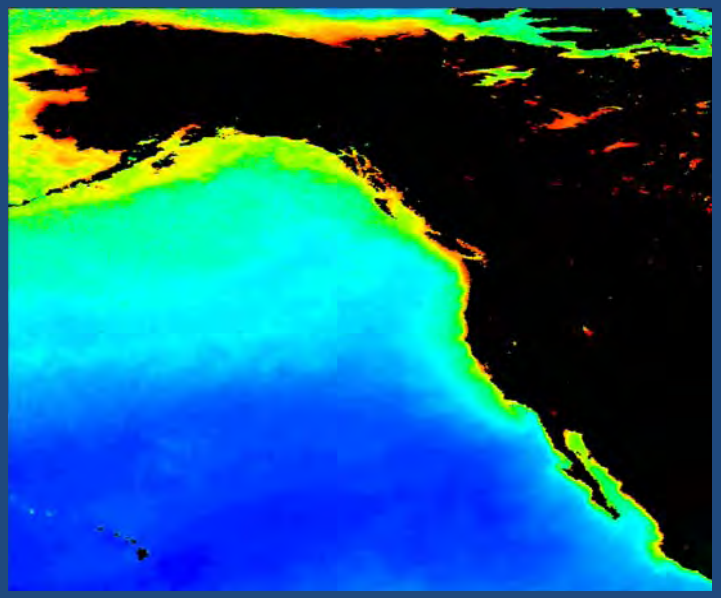
Macroecological patterns in North Pacific ecosystem dynamics:

Spatio-temporal co-variation in lower and upper trophic level diversity and productivity from Canada to Japan

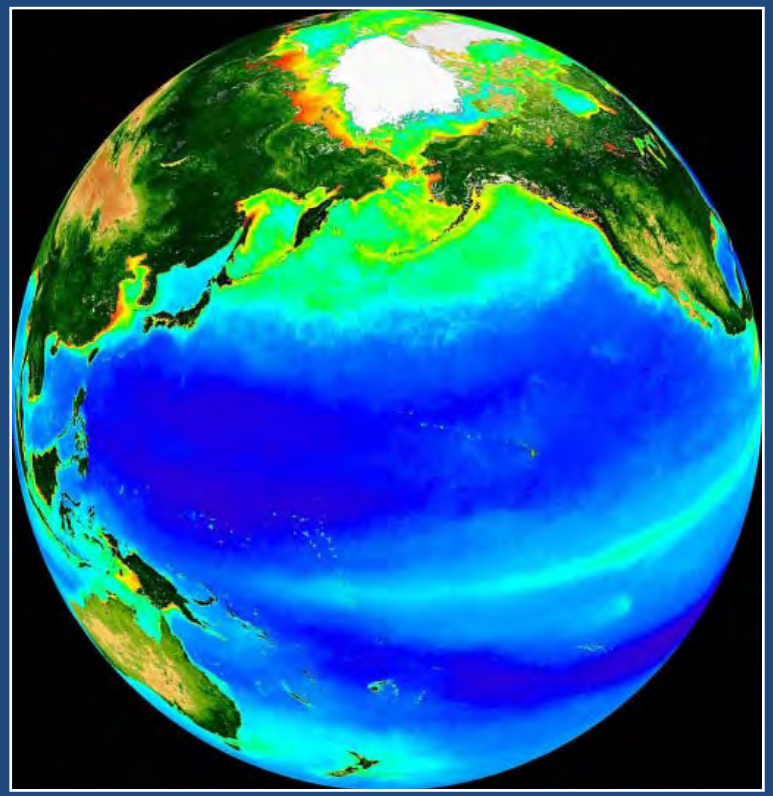


Mike Henry, Sonia Batten, David Hyrenbach, Ken Morgan, William Sydeman
mhenry@faralloninstitute.org

Macroecology:

The study of large-scale (1000s km) patterns and processes in ecology

(Hanley et al. 1978; Brown and Maurer 1989)



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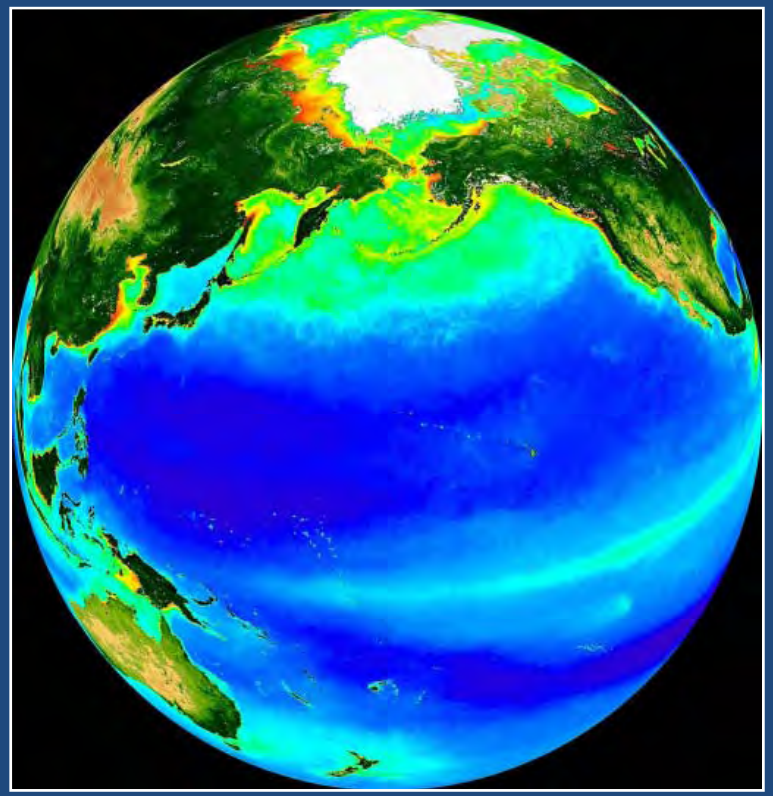

- ✯ Biodiversity

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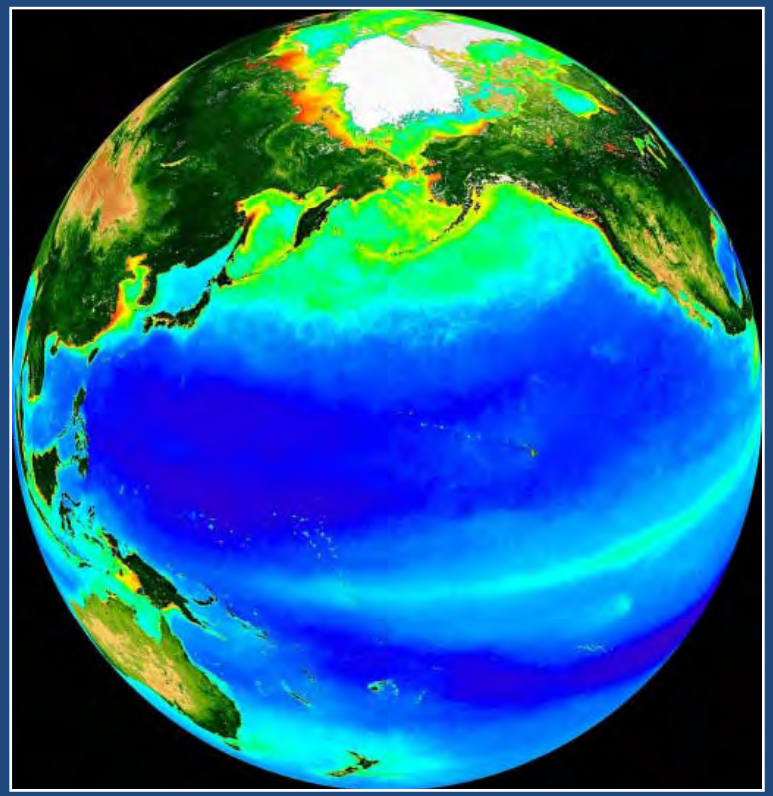

- ✯ Biodiversity
- ✯ Energy – Diversity Relationships

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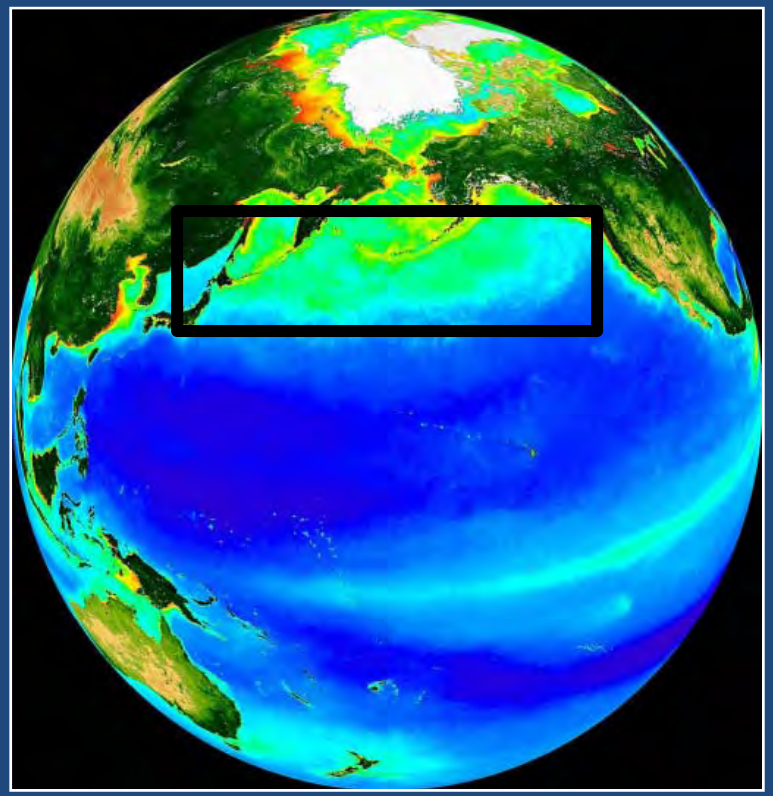


- ✯ Biodiversity
- ✯ Energy – Diversity Relationships

Purpose of CPR-MBM Project:

- Integrated Ecosystem Analysis

- Integration of multitrophic dynamics over large spatial scales

Testable Hypotheses

- Seabird/zooplankton abundance and community structure in the North Pacific is influenced by lower trophic level standing stock on a macroscale

Testable Hypotheses

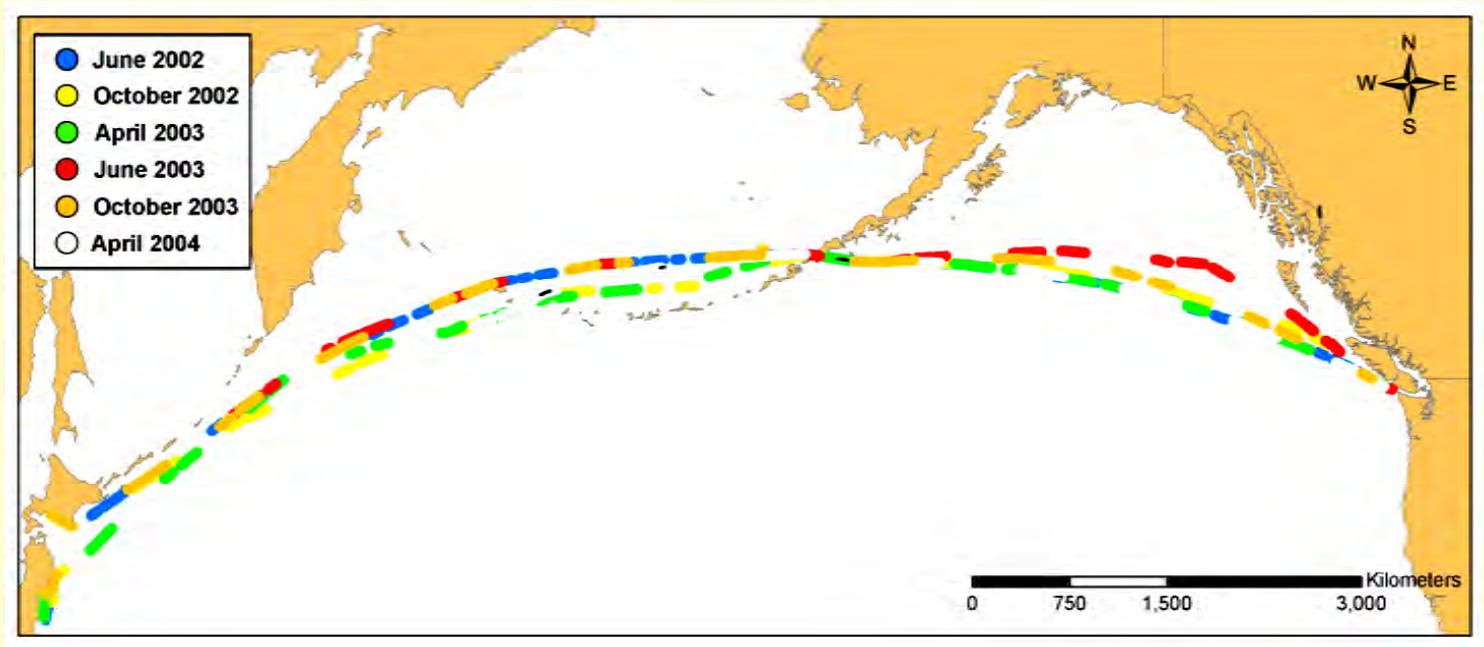
- Seabird/zooplankton abundance and community structure in the North Pacific is influenced by lower trophic level standing stock on a macroscale

- Seabird communities are shaped by lower trophic level biodiversity (species richness and diversity)

Methods: CPR-MBM Replicate Surveys

Surveys: 3 seasonal cruises/yr (2002-2007)

5 Spring (2003-7)
6 Summer (2002-7)
5 Fall (2002-6)



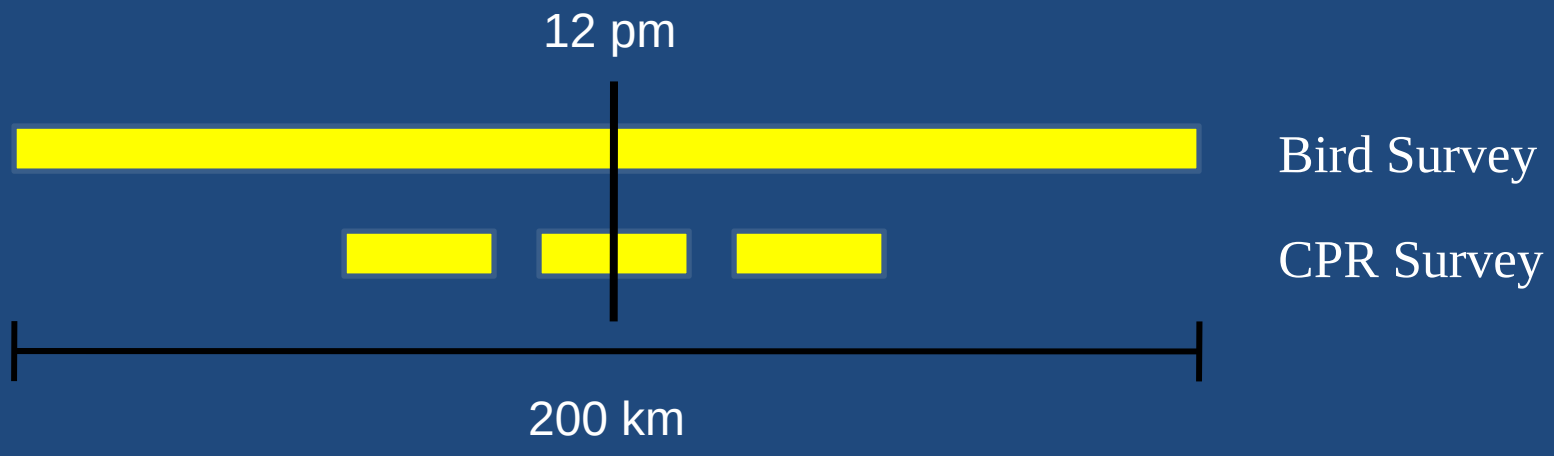
Seabird Observations

- East-West track
- 16 cruises to-date
- 199 daily transects
- 150-200 km daily

Continuous Plankton Recorder (CPR)

For Seabird Comparability:

- 3 subsamples (54 km)
  - 120 comparable transects



Net Primary Production

Vertically Generalized Production Model (VGPM)

(Behrenfeld and Falkowski 1997)

(http://web.science.oregonstate.edu/ocean.productivity)

Modeled from various satellite measurements

(Chl *a*, SST, PAR, Z_{eu})

Standing Stock Measures

- Abundance
- Biomass

Diversity Indices

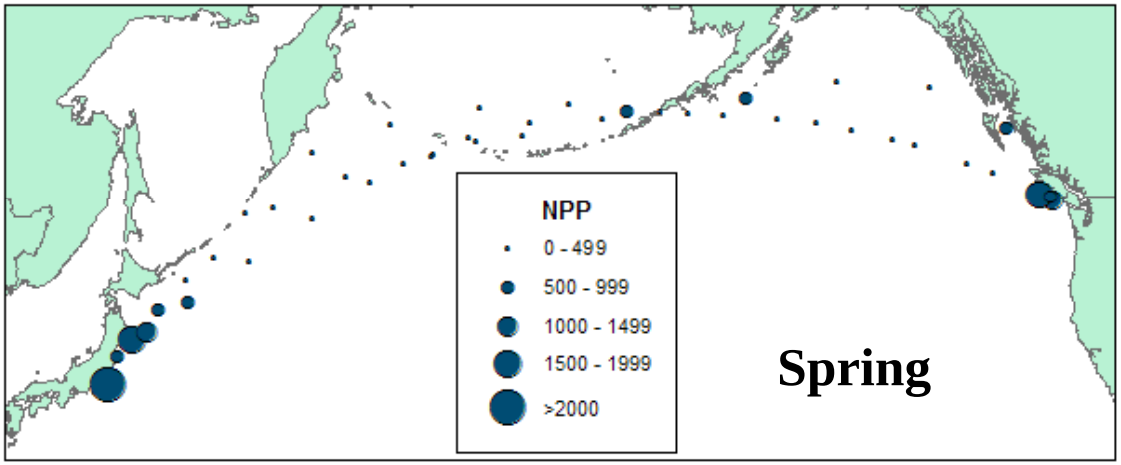
- Richness (Species/Genera per area)
- Diversity (Shannon's Index $-\sum p_i \log p_i$)
- Evenness (Peliou's J)

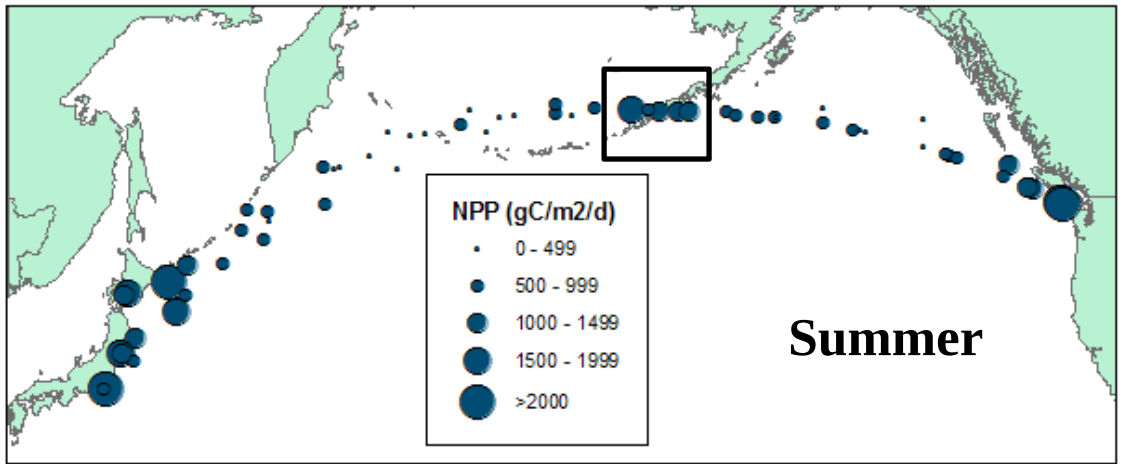
☆ **Issue:** Seabirds ID to species, Zooplankton ⇒ ~Genus

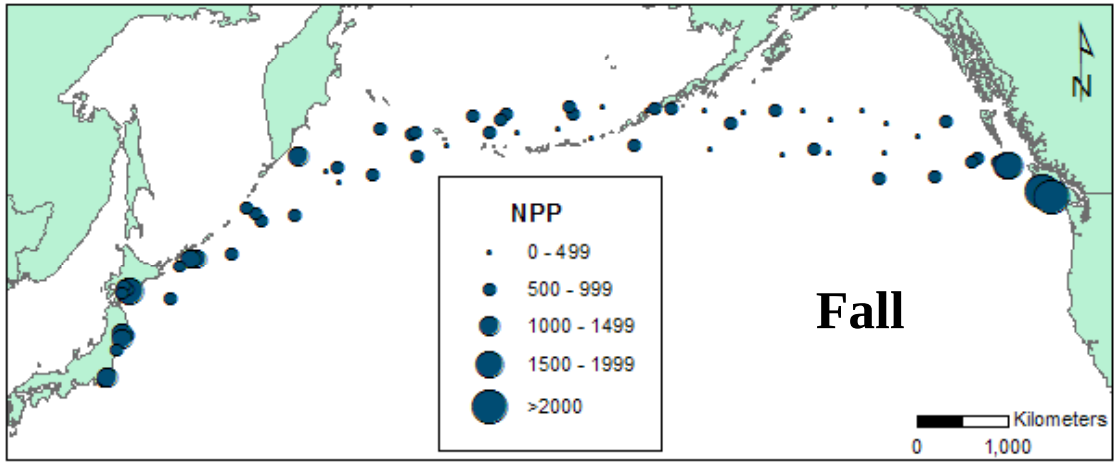
Relationship between Seabirds and Lower Trophic Levels

- GLM - Stepwise Multiple Regression

	Seabirds	**Lower Trophic Level**	
Bulk	Abundance	Abundance	Zooplankton
	Biomass	Biomass	
Diversity Indices	Richness	Richness	
	Diversity	Diversity	
		NPP	
		Depth	







Net Primary Productivity

(gC/m2/d)

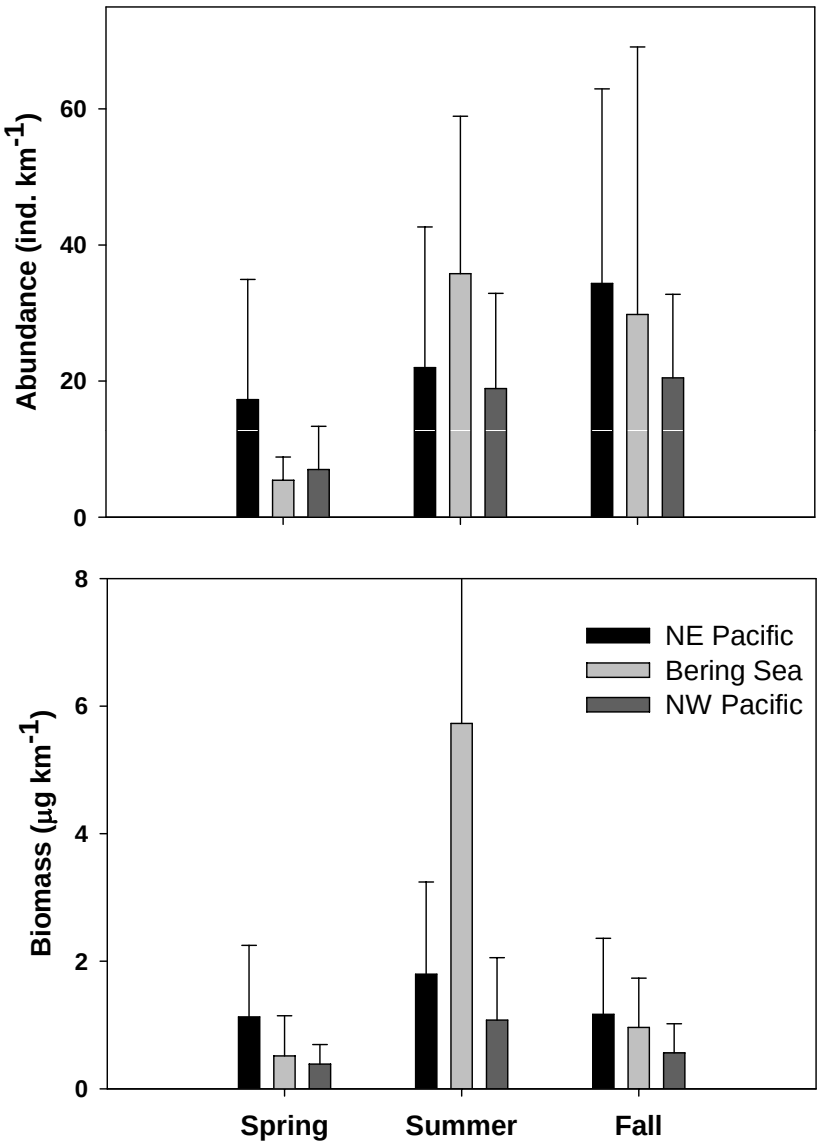
Season

Spring < (Summer, Fall)

Domain

Coastal > Oceanic

Seasonal and Basin-related Zooplankton Distributions



Zooplankton NPP Relationships

Spring

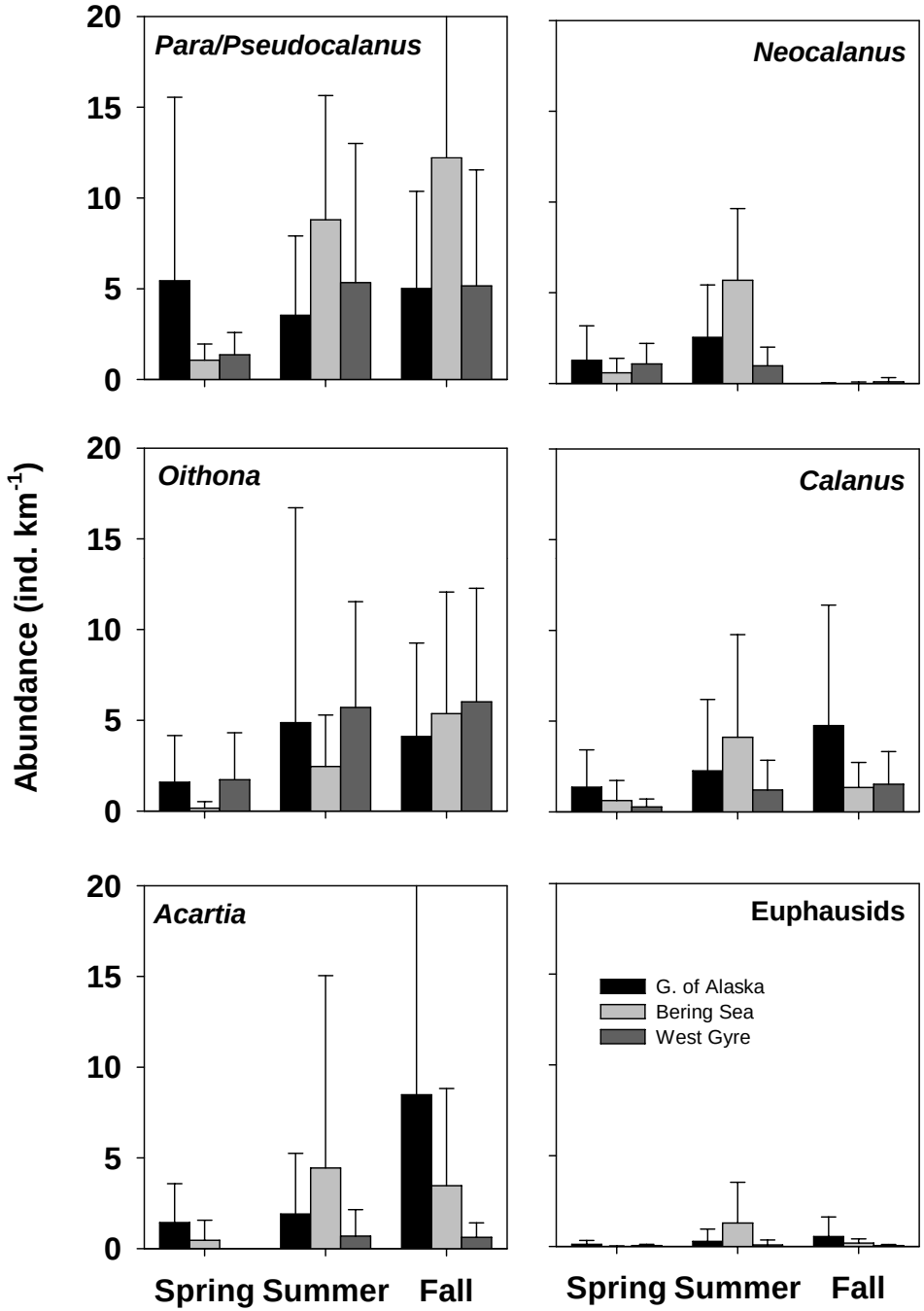
Abundance p=0.08
Richness p=0.05
Diversity p=0.06

Summer

All p>0.05

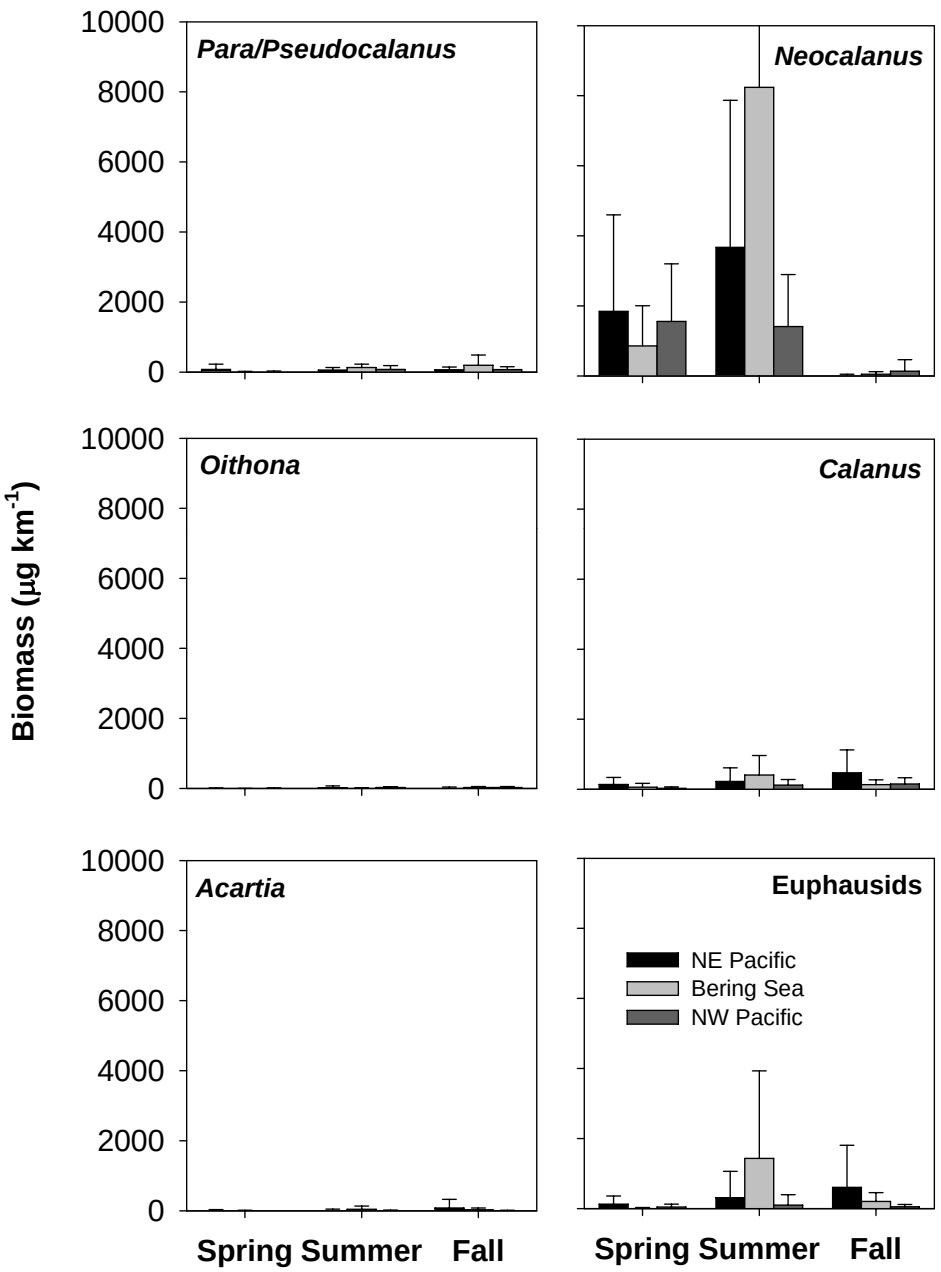
Fall

Biomass p=0.05
Richness p=0.02



Top Contributors: Zooplankton Abundance

Group	% total
Para/Pseudocalanus	***26.0***
Oithona	19.6
Acartia	12.5
Calanus	10.2
Copepod nauplii	9.9
Neocalanus	6.3
Euphausids	1.4
Eucalanus	0.3
Cumulative:	**86.1**



Top Contributors: Zooplankton Biomass

Group	% total	Body Weight (µg)	Abundance Rank
Neocalanus	**65.8**	**1448**	**6**
Euphausids	11.0	1114	11
Calanus	7.2	99	4
Eucalanus	2.8	1228	13
Para/Pseudo	***2.7***	**15**	**1**
Acartia	0.8	9	3
Oithona	0.6	4	2
Copepod nauplii	0.4	5	5
Cumulative:	**91.3**		

Do Seabirds track Zooplankton "Hotspots"?

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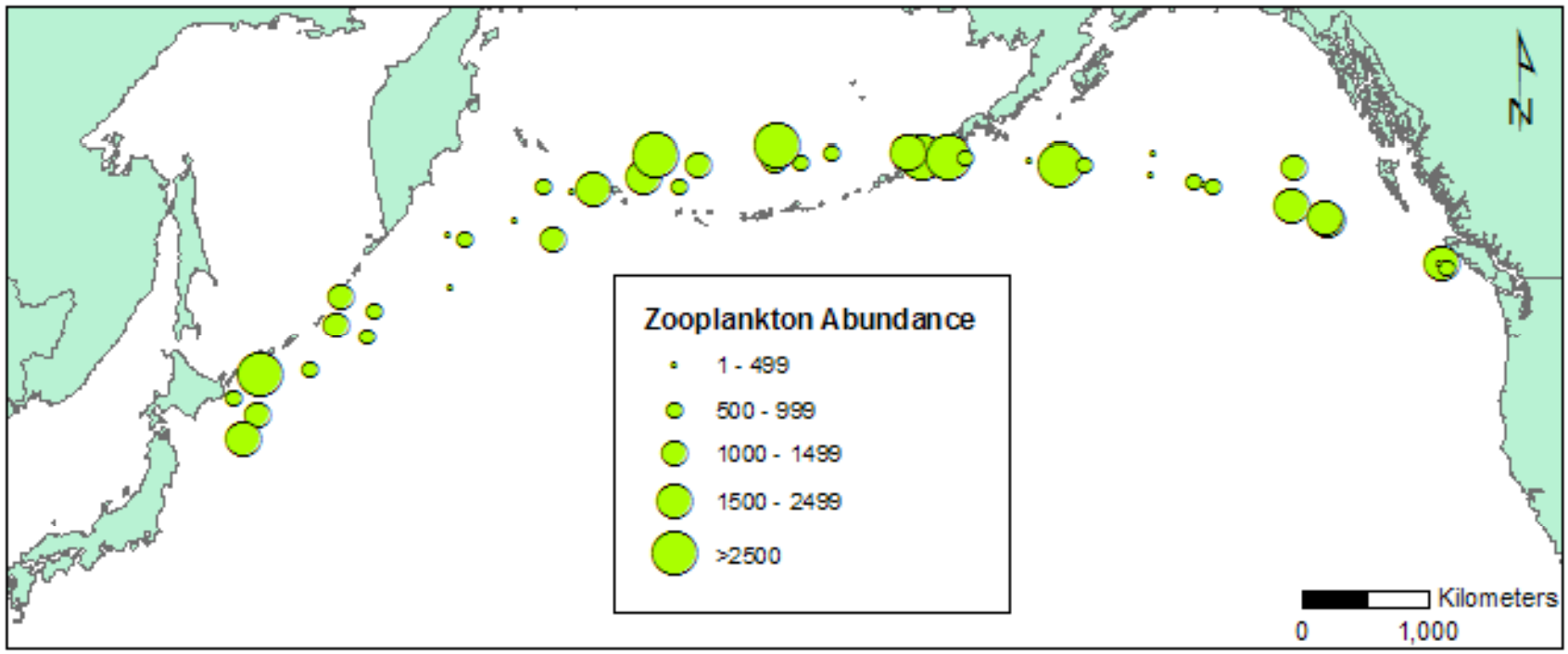
Photo: Mike Brittain

With 2 - 4 birds m^{-2}, this flock contained 4 - 9 million

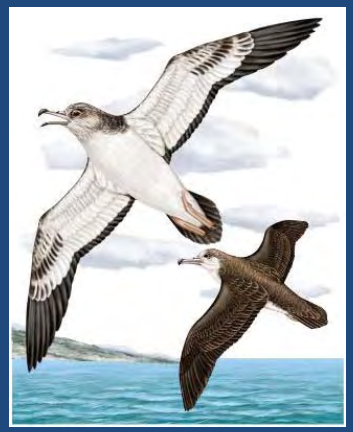
~ 13 – 30 % of the world population

Summer Zooplankton Abundance



Summer - Zooplankton Abundance (individuals/54 km)

Important Seabird Species

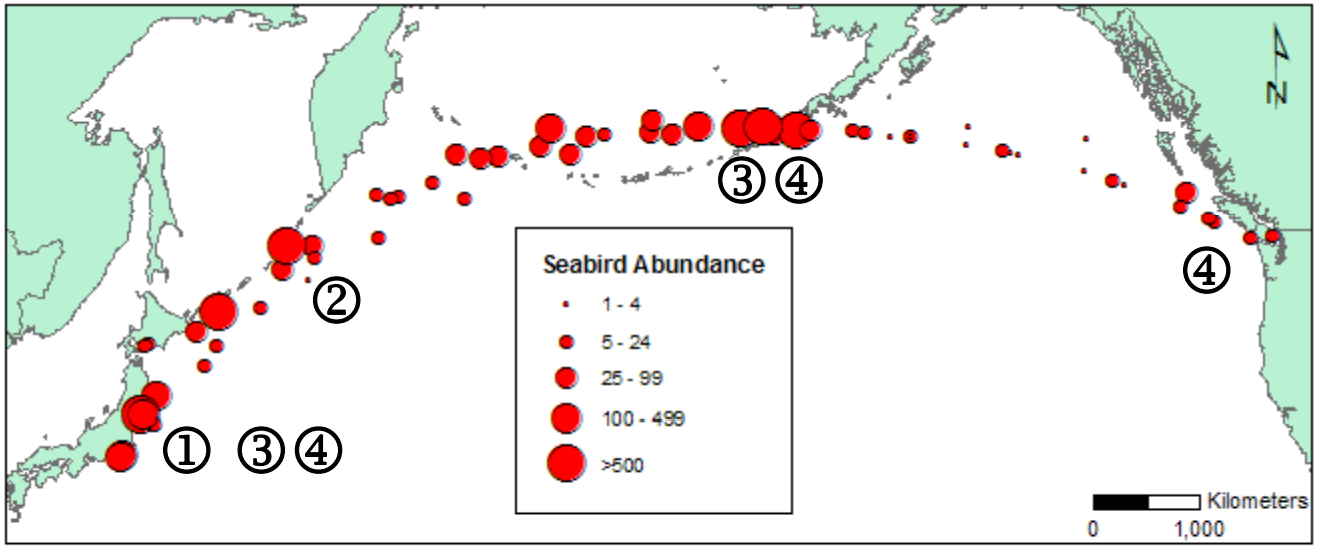


① Streaked Shearwater

② Crested Auklet

③ Short-tailed Shearwater

④ Sooty Shearwater



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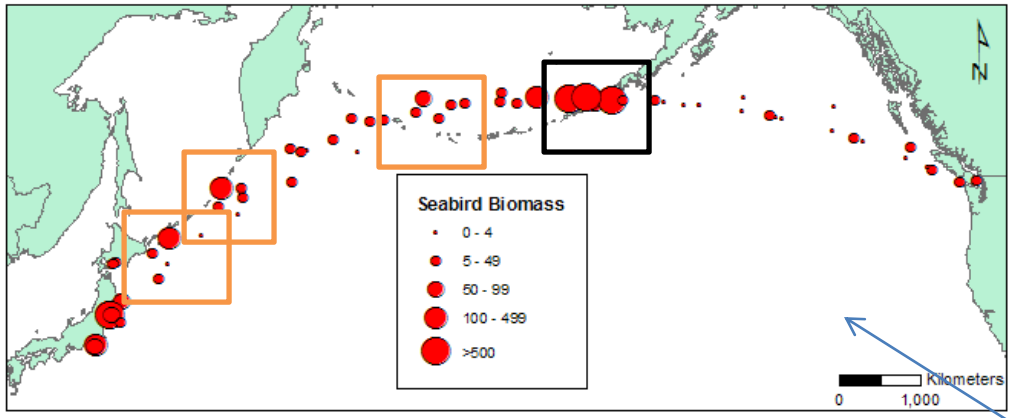
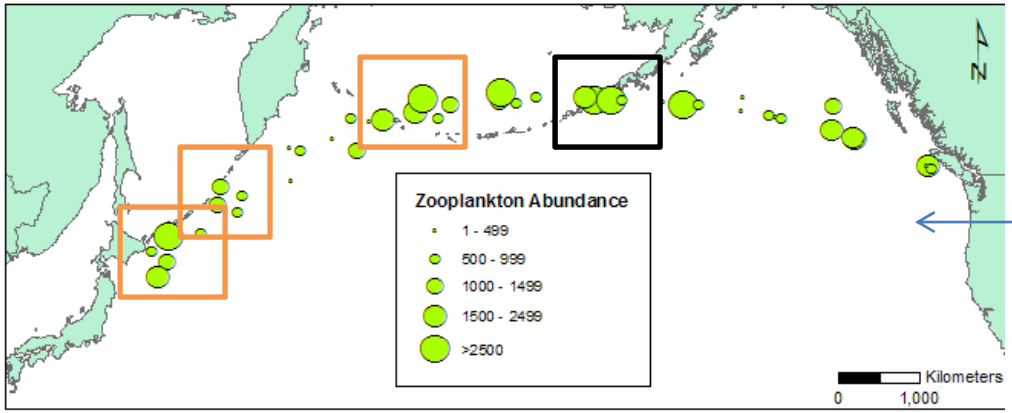


Summer - Seabird Biomass (kg/km2)



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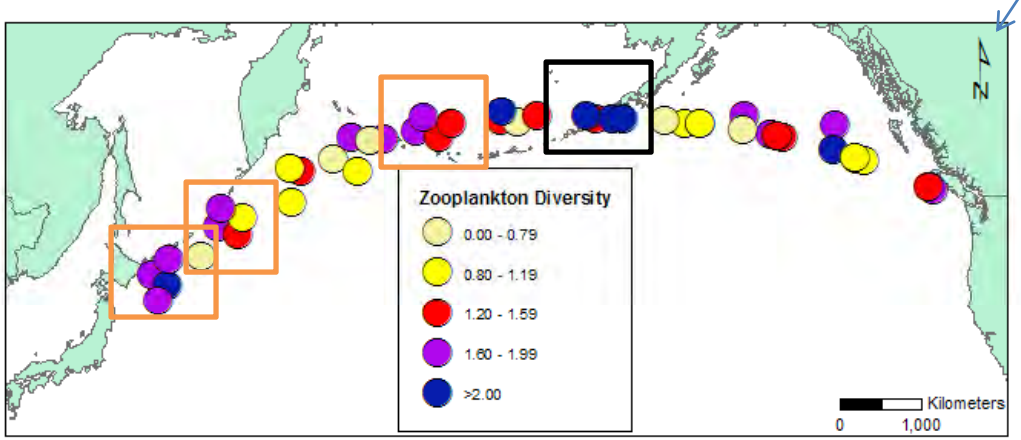
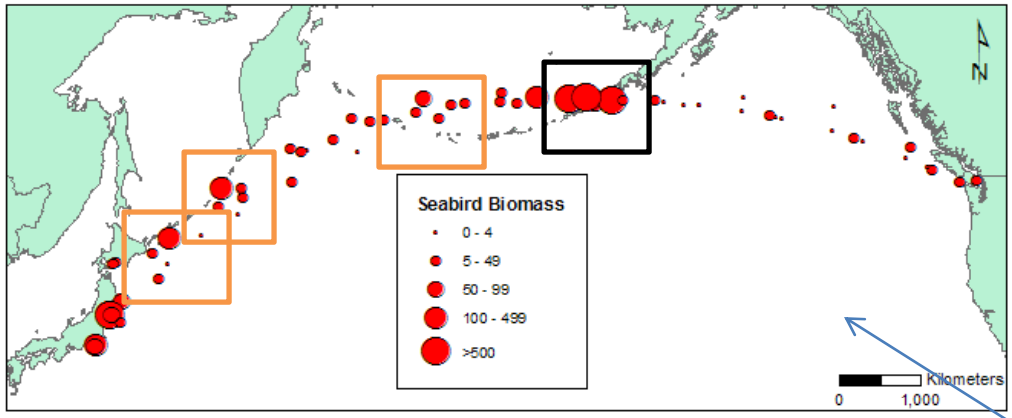


Summer - Zoopankton Diversity

Summer

Seabird	R^2	Sign Coeff
Abundance	**0.38**	*-Depth Richness*
Biomass	**0.41**	*-Depth Abundance*
Richness	**0.52**	*-Depth Abundance*
Diversity	0.11	*-Diversity*



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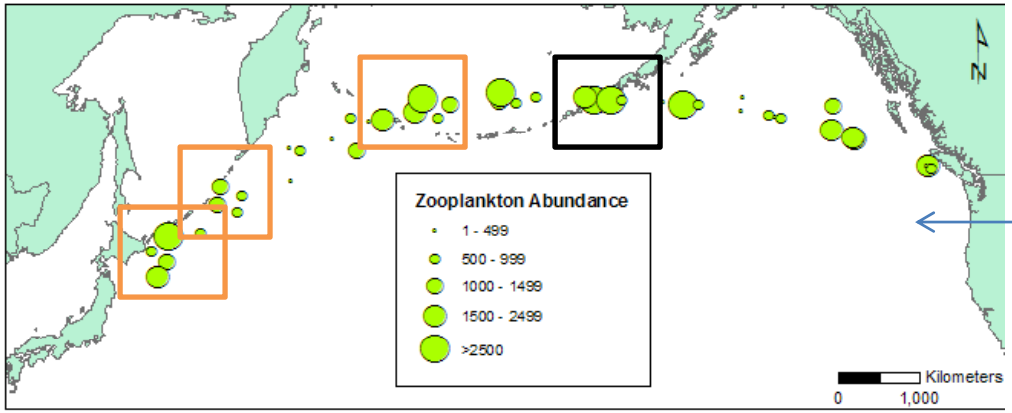

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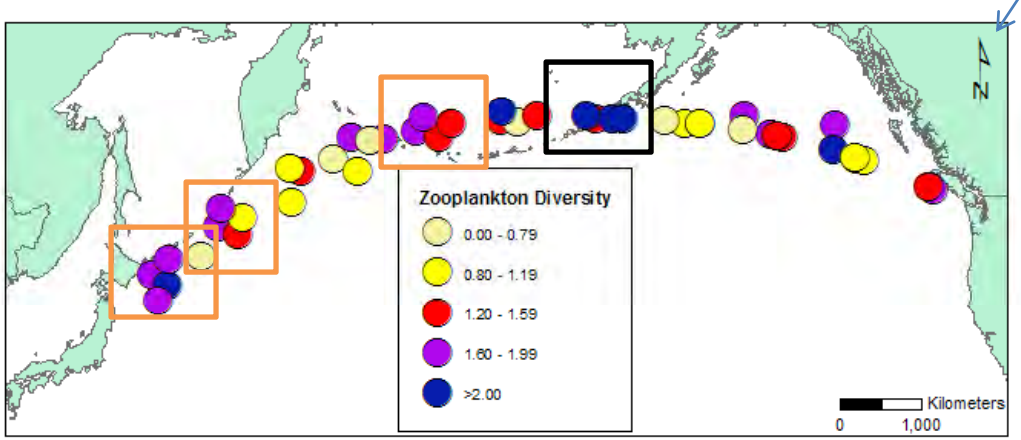

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✯ Coastal zone inundated with large flocks of migrants (STSH, SOSH) following species-rich, diverse, and abundant zooplankton communities

Going back to Original Hypotheses

1. Seabird abundance and community structure in the North Pacific is influenced by lower trophic level standing stock on a macroscale.

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2. Seabird community dynamics are shaped by lower trophic level biodiversity (species richness and diversity).

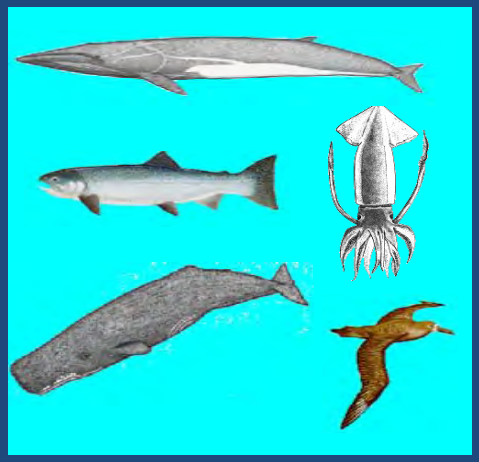
Yes. Seabird abundance and diversity is directly related to zooplankton richness and diversity.

General Summary

• Identified multitrophic level patterns and ‘hotspots’ over a large spatial scale

• Among the few marine studies that integrates the influence of diversity between multiple trophic levels, in addition to standing stock influence

• Concurrent macroscale lower-trophic and upper-trophic surveys provide integrated perspective of ecosystem structure and change



Acknowledgements

- North Pacific Research Board

- Masters and crew of the *M/V Skaubryn*

- Robert O'Malley (Oregon State U.)